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SECTION 1. INTRODUCTION

1.1 Intent

This document provides technical guidance to architects and engineers performing mechanical design services for Naval Facilities Engineering Command, Southern Division. If you have not done work for the government before, you should read this guide carefully prior to beginning work on Southern Division projects. Military construction requirements often differ from commercial practice and this guide provides a comprehensive listing of the mechanical and plumbing requirements for military projects. Direct requests for variances and/or suggestions for improvements to this document to Code 0733.

1.2 Other Guidance And Criteria Available

For further guidance and sources of criteria refer to the latest revision of:

- (a) SOUTHNAVFAC P-141, "Guide For Architect-Engineer Firms Performing Services For Southern Division, Naval Facilities Engineering Command."
- (b) "SOUTHNAVFAC Index Of Criteria" - Includes guide specifications, Design Manuals, Military Handbooks and other military publications.
- (c) "SOUTHNAVFAC Index Of Air Force Criteria" - Includes Force Manuals (AFM), Air Force Regulations (AFR), Air Force Instructions (AFI), Engineering Technical Letters (ETL) and other Air Force publications.
- (d) Requirements Documents (for Air Force projects only).
- (e) Parametric Cost Estimate (PCE) Package (for Navy and Marine Corps projects)

Most referenced documents are available on the internet at Southern Division's website at: http://www.efdsouth.navfac.navy.mil/Facilities_Acquisition/criteria/INDEX.HTM.

1.3 Industry Criteria

Naval Facilities Engineering Command has officially adopted the International Mechanical Code (IMC) and the International Plumbing Code (IPC) as the codes to be used for Naval facilities. These documents are available from Building Officials and Code Administrators International (BOCA). They may be reached at <http://www.bocai.org/> on the internet, or via telephone at 708-799-2300 or FAX 708-799-4981.

1.4 Design Process for Military Facilities

One of the first steps in the design of HVAC systems should be the preparation of the energy analysis as outlined in Section 7 of this guide. Bear in mind that your design will have to be altered if necessary to achieve the Design Energy Target for the facility. Therefore, it is recommended that you do not begin detailed system design until the energy analysis has been approved by Code 0733.

SECTION 2. HVAC DESIGN PARAMETERS

Note- Design temperatures listed in this guide comply with Department of Defense (DOD) standards and may not be as stringent as used on commercial projects. This is intentional to ensure that HVAC equipment is not unnecessarily over-sized.

2.1 Outdoor Design

Use outdoor design conditions indicated in Table 1. These figures are based on the 97.5% design temperatures listed in NAVFAC P-89, Engineering Weather Data. In humid areas, the wet bulb temperature has been selected based on the ASHRAE 99% design temperatures. Where **specialized** design requirements demand the use of more stringent outdoor conditions or if a project location is not included under Table 1, contact Code 0733 for direction.

2.2 Indoor Design

The conditions given below are intended for use in design calculations. HVAC controls shall be adjustable and may allow selection of temperatures above or below these design values. Specific design criteria are contained in MIL-HDBK-1191 for medical facilities, MIL-HDBK-1027 for training facilities, and MIL-HDBK-1012 for computer and electronics facilities.

2.2.1 Summer Indoor Conditions: The indoor design temperature for air-conditioned occupied spaces shall be 15°F (8.3°C) less than the outside dry bulb temperature, but not more than 78°F (25.6°C) or less than 75°F (23.9°C) dry bulb. The design indoor relative humidity shall be 50% maximum. Active humidity control of spaces is not normally required.

2.2.2 Winter Indoor Conditions: The winter indoor design temperature for personnel comfort shall be 68°F for administrative and living areas, 55°F (12.8°C) for working areas and 40°F (4.4°C) for storage areas subject to freezing. Warehouse facilities for the storage of materials not subject to freezing shall not be heated unless routinely occupied by workers.

2.3 Heating And Cooling Load Calculations

Perform calculations per the latest ASHRAE guidance. Exercise caution in using energy analysis calculations to size mechanical equipment. Process loads are not included in energy analysis calculations which could result in equipment being under-sized if the energy analysis calculations are used to size mechanical equipment.

SECTION 3. VENTILATION AND INDOOR AIR QUALITY

3.1 Ventilation Rates

Ventilation air is outside air provided by forced ventilation or by infiltration. Refer to the latest revision of ASHRAE Standard 62, "Ventilation For Acceptable Air Quality," for required ventilation rates. The following requirements are in addition to the rates recommended by ASHRAE:

3.1.1 Exhaust toilet areas, locker rooms, and janitor closets mechanically with an exhaust rate of not less than 2 cfm/ft² (10.2 L/s/m²) of floor area. For private toilet rooms with one water closet and one lavatory, exhaust air may be reduced to not less than 1 cfm/ft² (5.1 L/s/m²). Provide at least 50 cfm (23.6 L/s) exhaust for bathrooms and janitor closets. See paragraph 5.6 for additional requirements for locker rooms.

3.1.2 Provide mechanical and electrical equipment rooms with 10 air changes per hour or an exhaust rate to limit room temperature rise to 10°F (5.6°C) above the outdoor summer design dry bulb, whichever is greater. Provide thermostatic control for fans unless otherwise required by code. To ensure that equipment rooms containing combustion burners for boilers, water heaters, or furnaces do not operate as negative pressure areas, use supply fans rather than exhaust fans for ventilation.

3.1.3 Design refrigeration equipment rooms to comply with ASHRAE Standard 15, "Safety Code for Mechanical Refrigeration."

3.1.4 Family Housing: An outside air supply is not required for family housing and shall not be provided except in quarters for officers of flag rank (i.e.- admirals or generals). In quarters for officers of flag rank, provide conditioned outside air to the conditioned space not to exceed 10% of the total central air conditioning system capacity.

3.1.5 "Garden Style" Bachelor Enlisted Quarters (BEQs): "Garden Style" BEQs are sometimes constructed in lieu of traditional "dormitory" style BEQs. Garden Style BEQs resemble normal commercial 2 or 3 story apartment complexes and are typically equipped with direct expansion (DX) air conditioning systems. Conditioned outside air is not normally provided for these facilities. Achieve ventilation requirements by considering infiltration.

3.2 Building Pressurization

Supply outside air to the return plenum or return mixing box directly at central air conditioning system air handling units. For HVAC systems utilizing individual HVAC units such as heat pumps or fan coils, provide pre-conditioned outside air to each room or module via a separate supply register. Supply this air at indoor design conditions (i.e.- 70-75 degrees F, 21-24 degrees C, 50% RH). Also see paragraph 4.1. Provide adequate outside air to pressurize the building under design wind conditions and building exhaust but never lower than that required by paragraph 3.1. An outside air supply of approximately 115% of the exhaust rate is recommended. Provide air balance diagrams on drawings. Show the supply air quantity, return air quantity, outdoor air quantity, exhaust air quantity, and degree of building pressurization.

3.3 Filtration

Provide air filtration for occupied spaces with at least 35% dust spot efficiency and 75% arrestance. Comply with the latest edition of ASHRAE's Systems and Equipment Handbook guidance for selecting and specifying filters.

3.4 Attic Spaces

For residential construction, provide a ventilation rate of not less than 1.5 cfm/ft² (7.6 L/s/m²) of floor area for attic spaces. For other buildings, provide sufficient ventilation to limit the temperature rise in the attic to no more than 10 degrees F (5.5 degrees C) above ambient. Provide natural ventilation or mechanical ventilation and thermostatic control for the fan(s) to operate at and above the summer outdoor design dry bulb temperature.

3.5 Carbon Monoxide Detectors

In Family Housing containing fuel-fired appliances, provide UL 2034 listed line voltage operated residential carbon monoxide (CO) detectors. Detectors shall feature digital readout and shall be located and installed per the manufacturer's instructions.

SECTION 4. HVAC EQUIPMENT

4.1 Room Fan Coil Units

For large facilities located in humid areas (such as Bachelor Enlisted Quarters or office buildings), do not use room fan coil unit systems, individual air conditioners, or heat pumps unless dehumidified & reheated ventilation air is supplied to each unit or space by a separate makeup air unit and positive pressure is maintained in the space. (See paragraphs 3.1.4, and 3.1.5 for exceptions.) For small facilities (<3000 ft²) with DX air conditioning, a separate pre-conditioned outside air system is not normally required.

4.2 Air Handling Units

Provide coils with low bypass factors to ensure proper dehumidification. As required by the IMC, provide auxiliary drain pans under all cooling coils or units containing cooling coils located in attic spaces, above suspended ceilings, furred spaces, or any other space where condensation from the cooling coils may result in damage to surrounding materials. Provide a separate drain line for the auxiliary pan and extend to a conspicuous point to signal that the regular drain is restricted, or provide a float switch to de-energize the equipment if condensate enters the auxiliary drain pan.

4.3 HVAC Equipment With Multiple Compressors

HVAC equipment with multiple compressors shall have independent refrigerant circuits to provide redundancy and multiple steps of capacity control.

4.4 Cooling Towers

Over-size cooling towers to ensure adequate performance under adverse conditions and for future operational flexibility. Select cooling towers for 25% extra capacity but operate at design capacity. For example:

Design (Calculated) capacity = 1000 GPM (63.1 L/s)

Scheduled (Selected) capacity = 1000 GPM (63.1 L/s) X 1.25 = 1250 GPM (78.9 L/s)

Provide a note on the cooling tower schedule to indicate that the equipment is selected for 1250 GPM but will operate at 1000 GPM.

Size condenser water flow to chiller for the design flow rate, not the oversized tower flow rate. Cooling tower piping shall by-pass to the cooling tower's sump.

4.5 Electric Resistance Heaters

Provide a stage of electric heat for each 7-10°F (3.9-5.6°C) differential temperature for all heating coils above approximately 1 kW capacity. For example, for a 15°F (8.3°C) differential temperature coil, provide two steps of heating. Indicate the number of stages provided in the schedule. Also see paragraph 6.5.

4.6 Mechanical Equipment On Roofs

Minimize the placement of mechanical equipment on roofs. For example, provide split DX systems with condensing units mounted at ground level vice rooftop DX units. This minimizes penetrations through roofs, limits access on roofs, and promotes accessibility of the equipment to encourage proper maintenance.

4.7 Equipment Schedules

The HVAC equipment actually installed on a project may be different from that used as your basis of design. Therefore, mechanical equipment schedules shall reflect actual required equipment capacities as calculated, not capacities provided by manufacturers' catalog data. This helps ensure that the installed equipment is optimally sized for the application.

4.8 Refrigerants

4.8.1 Rehabilitation Projects- Investigate refrigeration equipment to be demolished under rehab projects to determine the type and quantity of refrigerant contained. For equipment containing a Class 1 Ozone Depleting Substance (ODS) refrigerant, indicate the type and quantity of refrigerant on the drawings. Require the use of refrigerant recovery/reclaim equipment to prevent release of refrigerant to the atmosphere. Class 1 ODS must be reclaimed and turned over to the Government. See NAVFAC guide specification section 02220 for additional requirements.

4.8.2 New construction- Navy regulations prohibit the installation of new equipment containing Class 1 ODS refrigerants. For larger refrigeration equipment (i.e.- 100 tons or larger), consider specifying equipment which uses HFC refrigerants vice equipment which uses HCFC refrigerants, which are scheduled to be phased out of production. This may help avoid increasing maintenance costs and the requirement for refrigerant conversions in the future.

4.9 Boilers

See section 11 of this guide for detailed boiler requirements.

SECTION 5. HVAC SYSTEMS

5.0 Types Of HVAC Systems

Base system selection on the capability of the air conditioning system to control the humidity in conditioned spaces continuously under full load and part load conditions. Consequently, chilled water HVAC systems will be preferred for many facilities.

5.1 Chilled Water Systems

5.1.1 Pipe Insulation: Provide cellular glass insulation with a vapor barrier for chilled water piping. **NO ALTERNATIVES WILL BE ALLOWED FOR PIPING INSIDE BUILDINGS.** For exterior piping, factory pre-insulated and jacketed chilled water piping which utilizes polyurethane foam and a PVC jacket may be used upon Code 0733 approval.

5.1.2 Chiller Plant: In the basis of design, provide a rationale with back-up calculations in support of the decision to use one or multiple chillers. Maintain constant flow through each chiller when multiple chillers are used. The combined capacity of the two chillers shall not exceed the total requirement, including diversity, unless there is a specific requirement for redundancy. Consult chiller manufacturers for recommendations for sizing each chiller in multiple chiller plants to provide the lowest energy usage. See paragraph 6.7 for guidance on multiple chiller controls.

5.1.3 Part-load efficiency of the chillers often has the greatest effect on operating costs because chillers spend most of their time operating at less than full load. Therefore, selection of the chiller capacity shall consider part load operating hours.

5.1.4 Chilled Water Temperature: Design chilled water distribution system and controls such that the maximum chilled water supply temperature at cooling coils will be 45°F (7.2°C). Do not use chilled water temperature reset in areas above weather region 8 (see Table 1 for weather region definitions).

5.1.5 Chilled Water Pumps: Provide backup (100% capacity) chilled water pumps to minimize outages for repairs or maintenance.

5.1.6 Primary/secondary Pumping: When more than one chiller is provided, consider the use of primary/secondary pumping with variable speed secondary pumps and two-way control valves to promote energy efficiency.

5.1.7 Minimum Chilled Water System Volume: For chilled water systems, the minimum volume of chilled water contained in the piping, valves, pumps, cooling coils, and chiller barrel(s) shall be not less than 7 gallons per ton (7.57 liters per kW) of nominal rated chiller capacity. If necessary, provide an insulated, in-line storage tank in the chilled water piping to achieve the required chilled water capacity. Install the chilled water storage tank downstream of the chiller and upstream of the cooling coils. Provide calculations to demonstrate compliance with this requirement. Volumes for components may be estimated where manufacturer's

information is not available. This requirement is intended to prevent short-cycling of the chiller(s) to promote long chiller life and good chilled water temperature control, especially in smaller chilled water systems.

5.2 Heating Systems

5.2.1 Steam heat should not be used except on rehabilitation projects where budget constraints preclude conversion to hot water.

5.3 Air Distribution Systems

5.3.1 Consider face and by-pass control for humid areas.

5.3.2 Do not use economizer cycles in areas above weather region 8 as the small reduction in energy usage is more than offset by increased humidity control problems. Dry bulb economizers may be used in weather regions 8 and below.

5.3.3 Outside Air: In humid areas, condition outside air through a continuously operating air conditioning system. See paragraphs 3.2 and 4.1. Provide a constant supply of outside air for all systems at all modulating ranges.

5.3.4 Ductwork: Provide round ductwork where space permits. Fibrous glass duct is prohibited. Piping, conduit, etc. penetrations into HVAC ductwork are prohibited.

5.3.5 Low Pressure System Design: For low pressure rectangular duct systems designed using the equal friction method, use 45 degree entries into branches from the main supply duct. Spin-in fittings and conical taps are allowed for round take-offs from rectangular duct. Provide manual volume dampers in each branch take-off after leaving the main duct to control branch air quantity. Do not use splitter dampers for air balancing.

5.3.6 Variable Air Volume (VAV) System Design: Use the static regain method for duct design. Provide round or flat oval ductwork for VAV systems. Provide minimum stops on VAV systems to ensure adequate outside air ventilation at all loads. Provide a constant supply of outside air to the central air handler to meet ASHRAE ventilation requirements.

5.3.7 Flexible Ducts: Use flexible duct only for connections to air distribution devices to adapt to minor offsets. Install flexible duct fully extended and of the minimum length required to make connections, but not greater than 6 feet (1.8 meters). Detail flexible duct connections on plans.

5.3.8 Duct Insulation & Duct Liner: Thermal duct insulation shall normally be applied to the exterior of the duct. Duct liner is not permitted for use as thermal insulation except in rehabilitation work. Thermally insulating duct liner may be used on rehab projects where it is impossible to install exterior duct insulation due to limited clearances, or where ductwork must be located outside the building. Duct liner may be used as acoustic treatment on all projects.

Duct liner shall have a smooth, cleanable, and fire-resistant airstream surface that will not support mold or mildew growth. Duct liner shall comply with NFPA 90A and 90B and MAIMA Publication AH124, "Fibrous Glass Duct Liner Standards".

5.3.9 Ductwork drawings: Always show outside dimensions of ductwork. Increase duct dimensions to compensate for duct liner when specified. Include note on the drawings "All Ductwork Sizes Shown Are Outside Dimensions."

5.4 Variable Air Volume (VAV) Systems

VAV Systems shall provide acceptable air circulation and proper outside air for all conditioned spaces regardless of the loading conditions.

5.4.1 Provide an air flow monitoring station in the outside air duct controlling the outside and return air dampers or a constant volume outside air fan to maintain the minimum outside air requirements. Constant volume outside air fans are the most reliable method of maintaining outside air rates and are preferred.

5.4.2 Show the location of static pressure sensor(s) on the HVAC system drawings.

5.4.3 Use return air fans only when absolutely necessary or when an economizer cycle is provided (see paragraph 5.3.2). Provide a detailed sequence of control and complete control schematics to explain fan tracking controls for supply and return air fans.

5.4.4 Use pressure independent VAV boxes. Do not use system-powered (also called "pressure dependent") terminal units.

5.4.5 Do not use low pressure terminal units since they are not easily controllable. Ensure velocity controller is capable of sensing the entire range of scheduled flow. Include a VAV terminal unit schedule on the drawings which indicates the required operating airflow range and pressure drop.

5.5 Direct Expansion (DX) HVAC Systems

5.5.1 DX Multi-zone and DX VAV Systems: DX multi-zone and DX variable air volume systems may be considered for small buildings (<3000 square feet) with multiple spaces with a variety of loads. When such systems are specified, the HVAC equipment and controls shall be provided by a single manufacturer and shall be intended to work together as a system. For other facilities, provide HVAC systems as specified elsewhere in this guide.

5.5.2 Refrigerant Piping: Avoid refrigerant piping runs longer than 50 feet (15 meters) unless specifically allowed by the equipment manufacturer. Size refrigerant piping per the manufacturer's recommendations.

5.6 Kitchen (Galley) HVAC Systems

5.6.1 Check project documentation to determine if air conditioning of kitchens is allowed. Follow the guidance in paragraph 5.6.2 below to provide nominal cooling to kitchen areas. No air shall be returned from the kitchen to the HVAC system.

5.6.2 Design dining facilities so that air flows from dining areas to kitchen areas to provide make-up air for kitchen exhausts. Maximize the use of dining area make-up air to the kitchen as this will provide secondary cooling for the kitchen staff. If additional make-up air is required for kitchen exhausts, provide push-pull kitchen hoods with built-in heated make-up air supply. Design kitchen hoods according to the latest edition of Industrial Ventilation, A Manual of Recommended Practice, published by ACGIH. Kitchen hoods with built-in make-up air shall be of the horizontal face discharge type. "Short circuit" hoods are prohibited. Provide control interlocks for supply and exhaust fans to ensure that the HVAC system balance is maintained and that the proper direction of airflow is maintained during normal operations.

5.6.3 Do not use evaporative coolers on kitchen supply air in humid areas (weather region 8 or above). The increased humidity of the ventilation air will negate any small cooling affect.

5.6.4 Provide a detailed air balance diagram on the drawings for every kitchen/dining facility design to show compliance with the ventilation requirements given above.

5.7 Locker Room HVAC Systems

Provide conditioned air directly into locker space and draw conditioned air from adjacent spaces. This uses the outside air required for human occupancy in the adjacent spaces for secondary air conditioning of the locker space and maintains locker spaces at a negative pressure with respect to adjacent spaces. No air shall be returned from the locker space to the building HVAC system.

5.8 Closets In Bachelor Enlisted Quarters (BEQs)

Navy guidance requires conditioned air to be supplied to closets in new BEQs for humidity control. Provide a supply register in each clothing closet in BEQ modules sized to provide approximately 20 CFM (10 L/s) to comply with this requirement.

5.9 Supports For Pipe And Duct Systems

Determine seismic requirements for building per ACOE TI-809-04, Seismic Design for Buildings. Designer shall calculate the Seismic Hazard Level (SHL) per the SMACNA Seismic Restraint Manual, Guidelines for Mechanical Systems, and applicable building codes. Design pipe and duct supports per the SMACNA Seismic Restraint Manual. Indicate support details and spacing requirements on the contract drawings. Be aware that even though a building may warrant seismic restraints, some piping and ducts may be exempt based on service, size, and location. See ACOE TI-809-04 and SMACNA Seismic Restraint Manual Chapter 3 for exemptions.

5.10 Testing And Balancing

5.10.1 Provide balancing valves, manual dampers, gages and temperature/pressure test ports, etc. in proper locations to ensure that water and air systems can be balanced. Manual dampers may be required in addition to automatic dampers. Provide manual balance dampers at all duct branch connections to air devices in supply and exhaust systems. Provide manual balance dampers in both the return and outside air ducts for constant volume systems.

5.10.2 When an existing system is modified, provide all information required for re-balancing in the construction documents.

5.10.3 Perform two season TAB work only when it is not feasible to balance HVAC systems in one season (e.g.- systems with a seasonally operated central boiler plant).

5.10.4 Variable speed drives on pumps or fans shall not be adjusted to achieve system balance. Balance systems with variable speed drives operating at between 55 and 60 Hz so that maximum operational flexibility is maintained. Replace fan drive pulleys as necessary to achieve air system balance. Throttle pump discharges to achieve system balance on water systems. Consider trimming pump impellers to achieve system balance on larger systems to achieve optimum operating efficiency.

5.10.5 For small HVAC systems (e.g.- a DX system for housing) edit the specifications to require limited TAB work commensurate with the complexity of the HVAC system.

5.10.6 For complex HVAC systems, provide commissioning of the HVAC systems per ASHRAE Guideline 1-1996.

SECTION 6. HVAC CONTROL SYSTEMS

6.1. General

Keep it simple! Provide the simplest HVAC controls that will accomplish the intended function.

6.2 Drawings

Show system control schematics and written sequence of controls on the drawings for each mechanical system. For direct digital control (DDC) systems, include an input/output points list and a system architecture schematic.

6.3 Control Valves

Provide schedules on the plans for automatic control valves showing the allowable flow coefficient (C_v). Select control valve C_v ratings so that maximum pressure drops are used within constraints of available pressures, pipe velocities, economy of design, and noise criteria.

6.4 Selection Of Temperature Control Zones

Group temperature control zones to have similar load profiles based on the intended usage throughout the day, month, and year. Place spaces that have widely fluctuating loads on separate zones. The following paragraphs provide additional guidance.

6.4.1 Provide a separate zone for each classroom.

6.4.2 Provide a separate zone for each conference room.

6.4.3 Where possible, provide one terminal unit for large single room zones to prevent multiple units from "fighting" each other. Where two terminal units are required to cool a single zone, provide a single thermostat.

6.4.4 Show location of all thermostats on the drawings.

6.5 Electric Heat Control

Provide Silicon Control Rectifiers (SCRs) when precise control is required.

6.6 DDC Systems

6.6.1 Prior to designing the DDC system, check with the Base Public Works or Base Civil Engineering office to see if an existing energy management network has been established on the base. Provide DDC equipment which is compatible with existing systems to the maximum extent practicable. Where use of a specific DDC system is mandatory, prepare a Justification and Authorization (J&A) for the use of proprietary DDC equipment.

6.6.2 For new buildings, DDC systems shall use all electric or electronic actuators. On rehab projects, eliminate pneumatics whenever possible.

6.6.3 For new installations, provide DDC equipment which is user-friendly and which maximizes compatibility with other manufacturers' equipment. ASHRAE's BACnet standard (ANSI/ASHRAE 135-1995) provides guidance on DDC system compatibility.

6.6.4 For small HVAC systems (i.e.- DX systems of less than ~10 tons) DDC controls may not be cost-effective. Consider the use of programmable electronic thermostats vice DDC on these facilities. If the choice of HVAC controls is unclear, contact Code 0733 for guidance.

6.6.5 Require the DDC installer to provide training for government facility personnel on all new DDC equipment. Provide training as required by the RFP for Design/build projects, or request guidance from the base Public Works or USAF Base Civil Engineering Office where the project is located.

6.7 Multiple Chiller Plants

When multiple chiller plants are provided, control the chillers by a single central chiller control panel provided by the chiller manufacturer. This is to ensure that the chillers are loaded and unloaded optimally for best performance, reliability, and energy efficiency.

6.8 Variable Air Volume (VAV) Systems

See paragraph 5.3 for requirements.

6.9 Boiler Controls

See paragraph 11.3.2 for requirements.

SECTION 7. ENERGY/ECONOMIC ANALYSIS

7.1 Purpose

The energy/economic analysis process is a systematic approach focused on selecting the most life-cycle cost-effective mechanical, lighting, and architectural systems, while maintaining compliance with design energy targets and meeting the project's funding constraints. Federal law normally requires that an energy analysis be prepared and approved for every new Government building, and for the major renovation of existing buildings (i.e.- where major changes are made to both the building envelope and the HVAC systems). While the emphasis is on energy conservation, occupant comfort, productivity and functional requirements of the building shall not be adversely affected by any energy conservation measure. Complete the energy analysis and submit it for approval as early in the design phase of the project as practicable.

7.2 Definitions

7.2.1 Energy Analysis- Calculations which predict the energy usage for HVAC, lighting, and domestic hot water for a facility, in units of power per unit of floor area per year.

7.2.2 Economic Analysis- A life cycle cost comparison of alternative HVAC systems for a facility. The energy analysis and the economic analysis are used together to select an HVAC system which complies with Federal energy usage guidelines and which has a low life cycle cost, rather than an HVAC system with the lowest first cost.

7.2.3 Design Energy Target- The Design Energy Target (DET) is defined as the maximum allowable calculated energy usage for the facility.

7.2.4 Design Energy Budget- The Design Energy Budget (DEB) is defined as the amount of energy which the facility is predicted to use as calculated by the energy analysis. The DEB must be less than or equal to the DET (see paragraph 7.8.d).

7.3 Types Of Projects

7.3.1 Design/Build Projects: For design/build projects, the economic analysis is normally not performed. Acceptable HVAC system alternatives will be stated in the Request For Proposals (RFP), along with the DET for the facility. The energy analysis is required to demonstrate that the facility complies with the DET. For your benefit, perform the energy analysis and submit it to Southern Division as early in the project as practicable. Failure to demonstrate compliance with the DET may require re-design and/or re-work on the project. Perform the energy analysis on the proposed HVAC system per paragraph 7.5 and prepare and submit the report per the applicable portions of paragraph 7.8.

7.3.2 Invitation for Bid (IFB) Projects: For these projects, a full energy/economic analysis is normally performed. Perform the analysis and submit a report per the remainder of this section.

7.4 Energy/Economic Analysis Input

For IFB projects, an Energy Analysis Input Data Sheet (Form 7-1) must be submitted and approved by Code 0733 prior to conducting the energy and economic analyses. Discuss systems selected for analysis with the activity and Code 0733 prior to submittal. Ensure all proposed systems meet the basic design requirements for the project. For Design/build projects, Form 7-1 may be submitted with the energy analysis.

7.4.1 Fuel Prices: Obtain utility costs and fuel prices from the UERS reports for projects at Naval installations. This information can be obtained from the Public Work's Division, Code 163 at (843) 820-7045. Ask if demand side management incentives are available from local utilities. Where no DUERS report records are available, obtain utilities and fuel costs from the local utility company or supplier.

7.4.2 Study Life: The study life for economic analyses shall be 25 years from the scheduled beneficial occupancy date (BOD) for the project unless directed otherwise.

7.4.3 Selection of Alternatives: The most important consideration when selecting alternative mechanical, lighting, and architectural systems is functionality. Examine only alternatives that are practical, which are proven to function properly and which meet the basic requirements for the facility. When possible, use passive features such as insulation and building orientation, vice active systems such as heat recovery systems or co-generation equipment to minimize energy consumption. Consider the building layout, operational schedule, and occupancy. See the suggested alternatives for lighting, architectural, and HVAC systems below.

7.4.3.1 Lighting: The energy consumption of lighting systems and the resulting air conditioning load frequently represent a large portion of the total building energy consumption. For guidance on the selection of lighting systems, refer to SODIV-TG-1004, "Technical Guidance For Electrical Design."

7.4.3.2 Suggested Architectural Alternatives:

- a. Exterior wall construction
- b. Roof construction
- c. Windows
- d. Building orientation

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7.4.3.3 Suggested HVAC Alternatives:

- a. Hydronic heating and cooling
 - 1. Chilled water
 - (1) Air-cooled chillers
 - (2) Water-cooled chillers
 - (3) Central system chilled water
 - (4) Single or multiple chillers
 - (5) Variable speed pumping
 - (6) Heat recovery from chiller for domestic water heating
 - 2. Heating
 - (1) Natural gas, oil, or combination fired boiler
 - (2) Central system steam or hot water
 - (3) Electric heat
 - 3. Air Side Equipment
 - (1) Constant volume air systems
 - (2) Face and by-pass air systems
 - (3) Variable air volume systems
 - (4) Multi-zone systems
 - (5) Terminal reheat systems
 - (6) Heat recovery from exhaust air for ventilation air pre-conditioning
- b. Direct Expansion (DX) systems
 - 1. Air-to-air heat pump systems
 - 2. Air-to-air air conditioning systems
 - (1) Electric heat
 - (2) Hot water heat
 - (3) Natural gas heat
 - 3. Air-to-water heat pump systems
 - (1) Closed circuit cooler & hot water boilers
 - (2) Ground loop

7.4.4 Design Energy Target (DET): Determine the applicable DET from Table 3 using the applicable Facility Types from Table 2 and the weather regions from Table 1. Where a new facility does not seem to fit any of the facility types listed, contact Code 0733 for guidance. DETs in SODIV-TG-1003 must be “weighted” to account for different facility types within one building and to account for operational hours which differ from those listed in Table 2. For example, for an adjustment for different facility types within one facility:

$$\text{DET} = \frac{(\text{facility type 1}) (\text{area 1}) + (\text{facility type 2}) (\text{area 2})}{(\text{total area})}$$

For an adjustment for differing operational hours:

$$\text{DET} = \frac{(\text{actual operating hrs})}{(\text{TG-1003 operating hrs})} \times (\text{TG-1003's DET})$$

Note that both adjustments may be required.

7.5 Energy Analysis

Once the analysis input data has been approved by Code 0733 (for IFB projects), perform the energy analysis. Include all expected non-process loads such as comfort air-conditioning, lighting, ventilation, and service hot water in the energy analysis. Process loads, such as energy required to temper outside air for ventilating paint spray booths, electrical energy consumed by computers and the associated cooling energy, service water heating for vehicle wash stations, etc., will not be included in the energy analysis.

7.5.1 Computer Analysis: Computer program used shall perform hourly energy and system analysis, simulating the heating and cooling loads, architectural features, operational schedules and mechanical system performance for each alternative. Use the design conditions indicated in Section 2 of this guide. Use weather data files for energy consumption calculations supplied with the analysis software. Alternatively, data may be taken from historical weather tapes, available from the Department of Commerce, National Climatic Center, Asheville, North Carolina. The preferred program for energy analysis is Trane Company's TRACE 600 program.

7.5.2 Simplified Analysis: For facilities with less than 3000 square feet (279 square meters) of gross floor area, a simplified analysis may be performed by hand calculations or by a computer program following the energy calculations methodology outlined in the latest edition of the ASHRAE "Fundamentals" Handbook.

7.6 Economic Analysis

Complete life cycle cost calculations to show the lowest life cycle cost alternative. Include first cost of equipment, energy costs, operation and maintenance costs, and replacement costs in the economic analysis. In some cases, there may be justification for omitting the economic analysis. For example, if there is a central chilled water system at the facility and similar buildings have already been designed and built, the choice of the HVAC system will be obvious. In these cases, contact Code 0733 for guidance.

7.6.1 Computer Programs: The Construction Criteria Base (CCB) contains several computer programs for use in performing life cycle cost analyses in the "Tools" section of the program. Included are:

- a. BLCC4, "Building Life-Cycle-Cost, NISTIR 5185."
- b. ERATES, "A Program for Computing Time-of-Use, Block, and Demand Charges for Electricity Usage, NISTIR 5186."
- c. LCCID, "Life Cycle Cost in Design, U.S. Army CERL."

BLCC4 or LCCID must be used for economic analyses. Economic analyses generated by other programs will not be accepted. BLCC4 and LCCID automatically incorporate appropriate

escalation rates and discounting techniques for Department of Defense MILCON and non-MILCON projects. ERATES is useful when the economic analysis incorporates demand side management savings. See paragraph 7.6.6 for an optional procedure for demand side management analyses.

7.6.2 First Costs: Base the first cost for each alternative on a detailed estimate of all initial costs associated with the procurement and installation of each system.

7.6.3 Energy Costs: All expected energy costs, including those associated with process loads and associated cooling costs.

7.6.4 Operation and Maintenance Costs: Recurring annual maintenance costs for servicing and up-keep of HVAC systems.

7.6.5 Replacement Costs: Replacement costs for equipment with a life expectancy of less than 25 years. Life cycle cost calculations shall include all costs for equipment replacement during the study period. Table 4 gives some guidance on expected mechanical equipment lives; however, the designer shall use judgment and experience when estimating equipment lives.

7.6.6 Economic Analysis for Demand Side Management: The use of ERATES requires substantial typing and proofing of information transferred from the energy analysis output to the ERATES input file. TRACE 600 users may simplify this process as follows. The TRACE Economics program can be used to calculate an annual energy cost based on the utility company's various energy rates, demand charges, etc. This annual energy cost can then be transferred directly into BLCC4 or LCCID with an electrical rate of \$1/kW-hr. This eliminates the need to re-enter all of the data.

7.7 System Selection

Normally, select the HVAC system with the lowest life cycle cost that complies with the DET. In some cases, there may be justification for selecting a system that does not have the lowest life cycle cost. Ensure that your report provides a logical justification for the system that you recommend for the facility.

7.8 Energy/Economic Analysis Report

After completing the energy/economic analysis, assemble the information in a packaged or bound report. When preparing the report, bear in mind that this report is kept on file and may be reviewed by officials not familiar with the facility. Therefore, ensure that your report clearly presents the systems that were analyzed, their energy usage, and their life cycle costs. The report shall clearly identify the recommended HVAC system and the reasons it was chosen. Include the following items in the report:

a. The reviewed and approved Energy Analysis Input Data Sheet (Form 7-1)- Where input data is approved via telephone/fax, include a copy of the telephone memorandum, indicating the Code 0733 mechanical engineer contacted and the date of the contact.

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b. Energy Analysis Summary Sheet (Form 7-2). Clearly indicate the HVAC system which was selected.

c. A complete set of computer input and output printouts from energy and economic programs.

d. If the DEB exceeds the DET and all cost effective energy conserving measures have been included, notify Code 0733 prior to submitting the report. Attach a written request for a waiver to the DET to your report.

7.9 Requirements For Air Force Projects

Comply with ETL 94-4 (8/94), "Energy Budget Figure (EBFs) For Facilities In The Military Construction Program" or the latest applicable revision of this document for Air Force Projects. Refer to the Mechanical Section of the Requirements Document for other mechanical requirements and/or recommendations. Forward all applicable documentation (e.g., meeting minutes) with the Energy Input Data Sheet. Contact the PM immediately to verify base requirements and recommendations other than what is shown in the Requirements Document and/or other official correspondence.

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FORM 7-1 ENERGY ANALYSIS INPUT DATA SHEET					
Date					
Project Title					
Project Location					
Construction Contract Number					
Description of facility, including size and function					
Special temp. or humidity control requirements					
Design Energy Target (DET)					
Summer Outdoor Design Conditions				Summer Indoor Design Conditions	
Winter Outdoor Design Conditions				Winter Indoor Design Conditions	
Wall U-value:		Roof/ceiling U-value:		Glazing type:	
Lighting levels				Personnel loading	
Internal Process Loads					
Operational Schedules					
Approximate Cooling Load				Approximate Heating Load	
Estimated domestic hot water consumption					
Fuel prices					
Study Life					
Energy Analysis Program				Economic Analysis Program	
Descriptions of alternatives considered and rationale for consideration of each alternative. Include type of control system proposed. Attach additional sheets as necessary.					
Alternative 1.					
Alternative 2.					
Alternative 3.					
Alternative 4.					

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FORM 7-2 ENERGY ANALYSIS SUMMARY SHEET		
Date		
Project Title		
Project Location		
Construction Contract Number		
Design Energy Target (DET)		
Alternative 1		
Description	Life cycle cost	Design Energy Budget (DEB)
Alternative 2		
Description	Life cycle cost	Design Energy Budget (DEB)
Alternative 3		
Description	Life cycle cost	Design Energy Budget (DEB)
Alternative 4		
Description	Life cycle cost	Design Energy Budget (DEB)
Selected alternative and rationale for selection		

SECTION 8. INDUSTRIAL VENTILATION SYSTEMS

8.1 General

Design industrial ventilation systems per the latest edition of Industrial Ventilation, A Manual of Recommended Practice published by ACGIH. For Navy projects also comply with Military Handbook 1003/17. Air Force projects shall comply with AFOSH Standard 161-2.

8.2 Design Guidelines

8.2.1 Research the process or operation before design starts (i.e., find out contaminants, toxicity, process temperature, etc.).

8.2.2 Design hoods for effective capture of contaminants while minimizing air flow for energy conservation. Do not specify a canopy hood unless process is nontoxic. Indicate required capture velocities and capture distances for all hoods on the drawings. Provide notes and contractor instructions on plans indicating that fan airflows shown for hoods are approximate and requiring the contractor to balance the system to achieve the capture velocities indicated. The scheduled fan and motor size should allow for adjustment of the airflow.

8.2.3 Specify the appropriate fan for the application. When selecting a fan, consider noise generation, material handled through the fan (e.g., corrosives, flammables, etc.), and future expansion or flexibility of the system.

8.2.4 Provide tempered make-up air for all ventilation systems. Ensure that make-up air does not cause turbulence at the exhaust hood. Interlock make-up air fan to exhaust fan. Do not recirculate exhaust air.

8.2.5 Provide an offset discharge stack, with drain, for exhaust systems. Do not use a "conical cap" exhaust stack. Provide at least 25 feet (7.5 m) between exhaust outlets and outside air inlets to prevent circulating contaminated exhaust air back into the building.

8.2.6 Provide an air cleaning device when required by state and federal regulations. Select air cleaning devices that will maximize contaminant removal and ease of maintenance while minimizing cost.

8.2.7 Provide air flow and static pressure calculations with each design following the methods of the ACGIH Ventilation Manual.

8.3 Battery Shop Ventilation Guidelines

8.3.1 General: Contact manufacturer of the batteries to be charged for additional criteria associated with various battery types.

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8.3.2 Lead Acid Shops: Provide a minimum ventilation quantity of three air changes per hour or 400 CFM, whichever is greater. Perform calculations to document that ventilation will limit hydrogen buildup to less than 1% based on room volume.

8.3.3 Nickel-Cadmium (NICAD) Shops: Provide a minimum ventilation quantity of one air change per hour. Provide air conditioning or mechanical ventilation in the NICAD shop to limit the temperature to 85°F (29.4°F). If battery shop air conditioning is part of a general building air conditioning system, exhaust the shop's air directly to the outdoors. Do not return battery shop air to the air distribution system.

8.3.4 Local Exhaust: Use local exhaust ventilation where possible. Design local exhaust per ACGIH with a minimum capture velocity of 125 fpm (0.635 m/s).

8.3.5 General Dilution: If local exhaust is not practical, use general dilution ventilation. Slope shop ceilings 1/2 inch per foot. Use low point supply with 100% outside air. Provide high point exhaust equal to 110% of outside supply air quantity. Use non-sparking fan wheels and require motors to be located outside of the air stream.

8.3.6 Charging: Interlock chargers with exhaust fans to prevent charging without adequate ventilation.

SECTION 9. PLUMBING SYSTEMS

9.1 Criteria

Design plumbing systems per the latest edition of the International Plumbing Code (IPC).

9.2 Service Water Heating

For facilities that have high anticipated hot water usage rates, consider heat recovery from mechanical equipment. Perform a life cycle cost analysis to decide if heat recovery is economically advantageous for the particular facility.

9.2.1 Temperature Control: Equip service water heating systems with adjustable thermostats. Hot water temperatures for non-medical facilities shall be 120°F-140°F (48.9°C-60°C). Store hot water at not less than 120°F (48.9°C) to inhibit the growth of harmful bacteria. Unless conditions demand otherwise, don't heat and store water at higher than utilization temperature. Where special functions such as dishwashing require a higher temperature, provide a local booster rather than heat all hot water to the higher temperature.

9.2.2 Showers: Provide tempering valves at the point of source (water heater) or at the point of use (showers) to ensure that the maximum temperature of hot water supplied to showers is 120 degrees F (49°C) to prevent scalding.

9.2.3 Temperature maintenance: Where long runs of hot water piping are required, provide a means of maintaining hot water temperature per paragraph 607.2 of the IPC.

9.3 Roof Drainage Systems

For projects with secondary (emergency) roof drains, the plumbing engineer shall be responsible for verifying that scupper systems comply with all requirements of the IPC.

9.4 Natural Gas

Install meters for gas service to the building. Where gas distribution systems are owned by a local utility company, verify if that company will provide the meter and/or pressure regulator. If so, provide a note on drawing which indicates the meter and/or pressure regulator will be provided by the utility company and indicate the company's name.

9.5 Compressed Air And Vacuum Systems

Design per DM 3.05, "Design Manual for Compressed Air and Vacuum Systems". For medical gas or breathing air systems, design per MIL-HDBK-1191, "Medical and Dental Treatment Facilities".

9.6 Plumbing Vents

Minimize the number of roof penetrations by combining plumbing vents or by using air admittance valves as allowed by the IPC.

9.7 Emergency Showers

Where emergency showers are required, provide a column-mounted combination unit on a floor flange per ANSI Z358.1. Shower shall be designed so that components can be operated individually from a common fixture supply line. Provide a pressure-compensated tempered water supply with temperature held between 60°F and 95°F (15.6°C and 35°C). Size water heater to supply tempered water for not less than 15 minutes.

9.8 Minimum Water Pressure

Design plumbing systems for new facilities to provide at least 25 PSIG (172 kPa) to flush valve toilets. This is required to ensure efficient purging of the low volume (1.6 gallons per flush, 6 liters per flush) water closets required by the IPC.

SECTION 10. PETROLEUM FUEL FACILITIES

10.1 General

Petroleum fuel facilities require that the designer be familiar with the current criteria in MIL-HDBK-1022 "Petroleum Fuel Facilities," NFPA regulations and API publications. Navy and Air Force criteria and design aids as listed below are available from Code 0733.

10.2 Navy Criteria

10.2.1 Manuals:

MIL-HDBK-1022A "Petroleum Fuel Facilities"
 MO-230 "Maintenance and Operations of Petroleum Facilities"
 NAVAIR 00-80T-109 "Aircraft Refueling NATOPS Manual"

10.2.2 Definitive Drawings:

NAVFAC Drawing No.	Title
1404000	Aircraft Direct Fueling System Site Plans and Notes
1404001	Aircraft Direct Fueling System Flow Diagram
1404002	Aircraft Direct Fueling System Sequence of Operation
1404003	Aircraft Direct Fueling System Miscellaneous Details
1404004	Refueler Truck Loading System Plans, Sections and General Notes
1404005	Truck Unloading System Plan, Section and General Notes
1403995	Non-Polluting Fuel Pier
1404351	Offshore Tanker Facilities
1311350	Typical Tank Farm Layout

10.3 Air Force Criteria

10.3.1 Design Manuals: AFM 85-16 "Maintenance of Petroleum Systems"

10.3.2 Engineering Technical Letters

10.3.3 Standard Designs: Obtain from the Army Corps of Engineers, Huntsville Division (phone 256-895-1402).

AW 78-24-28 "Pressurized Hydrant Fueling System Type III
 AW 78-24-29 "Air Force Standards Aircraft Direct Fueling System (Type IV & V)"
 AW 78-24-27 "Standard Aircraft Bulk Fuel Storage Aboveground Steel Tanks With
 Floating Pan and Cone Roof"

10.4 Rehabilitation Projects

Test all above ground storage tanks and piping for lead based paint.

SECTION 11. HEATING PLANTS, BOILERS, AND PIPING SYSTEMS

11.1 Navy Criteria

11.1.1 Manuals and Standards

MIL-HDBK 1003/3	HVAC And Dehumidifying Systems
MIL-HDBK 1003/6	Central Heating Plants
MIL-HDBK-1003/8	Exterior Distribution Of Utility Steam, Temperature Hot Water, Chilled Water, Fuel Gas, Compressed Air
MIL-HDBK-1190	Facility Planning And Design Guide
ANSI B31.1	Power Piping Guide
ANSI B31.9	Building Services Piping Code
ASME CSD-1	Controls And Safety Devices For Automatically Fired Boilers
ASME Boiler And Pressure Vessel Code Section I -	Power Boilers
ASME Boiler And Pressure Vessel Code Section IV-	Heating Boilers

11.2 Heating Plants

When selecting hot water distribution systems, use low temperature vice medium temperature and medium temperature vice high temperature where practical.

11.3 Boilers

11.3.1 Boiler Installation Requirements

11.3.1.1 Location: Install boiler(s) and associated hot water pumps in a mechanical room inside the facility. Do not locate boilers outdoors without written approval from Code 0733. See paragraph 3.1.3 for other location restrictions. Provide ample clearance around boilers to allow access for inspection, maintenance, and repair. Passageways around all sides of boilers shall have an unobstructed width of 36 inches, or the clearances recommended by the boiler manufacturer, whichever is greater.

11.3.1.2 Temperature Requirements: If reset of the supply temperature is desired based on outside air temperature, use a mixing valve to achieve the desired supply temperature. Do not reset the temperature of the water in the boilers.

11.3.1.3 Combustion Air: Provide supply of air for combustion and ventilation. Calculate the amount of combustion air necessary to operate the boiler used as the basis of design. Provide supply fans for ventilation so that boiler rooms are not subjected to negative pressures which may interfere with combustion. (See paragraph 3.1.2.)

11.3.1.4 Drawings: Show boiler hot water isolation valves, emergency shutdown switch, and complete boiler gas train on the contract drawings.

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11.3.1.5 Sequence of Operation: Local, manual starting of boilers is required. Remote starting and stopping of the boiler by the HVAC control system is not permitted. This is to ensure that an operator witnesses the initial firing of the boiler at the beginning of each heating season to verify proper operation of the boiler and to promote proper maintenance. Energizing the boiler shall also start the heating water pump(s) to minimize thermal shock. Once energized, boilers shall maintain set temperature by cycling under factory boiler controls.

11.3.2 Boiler Requirements

11.3.2.1 General Requirements: Design, construction, installation, testing, and operation of boiler and appurtenances shall comply with the IMC, UL 795, NFPA 8501, ANSI Z83.3, ASME CSD-1, ASME BPVC SEC I and SEC IV (as applicable), the manufacturer's instructions, and the requirements of this section.

11.3.2.2 Boiler Type: The following boiler types are required to be used on all Southdiv projects. These boiler designs have been selected on the basis of having excellent durability, resistance to abuse, long lives, and reasonable efficiency. Alternative boiler types are not allowed without prior approval of Code 0733.

- a. Below 400,000 BTUH (117kW) input: Provide cast iron sectional boilers with atmospheric burners.
- b. 400,000 BTUH (117kW) -1,000,000 BTUH (293 kW) input: Provide steel firetube firebox type with power burner or modified Scotch marine type with power burner. If space constraints dictate, cast iron sectional boilers with power burner may be used.
- c. Above 1,000,000 BTUH (293 kW) input: Provide modified scotch marine type with power burner up to approximately 15,000,000 BTUH (4395 kW) input. Above this level, provide packaged steel watertube boilers.

11.3.2.3 Efficiency: Boilers shall have a steady state combustion efficiency of at least 80 percent when fired at the maximum and minimum capacities that are allowed by the controls.

11.3.2.4 Burners: Burner type shall be per the requirements above and the IMC. Interrupted pilot type ignition system and pilot shall be the electrode-ignited natural gas type. Burner shall be the make, model and type certified and approved by the manufacturer of the boiler being provided. The combustion safeguard system shall have a repetitive self-checking circuit that shall automatically check all components of the combustion safeguard system including the flame detector. Design burner and combustion control equipment for firing natural gas having a specific gravity of 0.6 and a heating value of approximately 1,000 BTU per cubic foot (37,300 kJ per cubic meter) and as an integral part of the boiler. Provide a high-low-off combustion control system for boilers rated up to 1,673,750 BTUH (490 kW). Provide full modulation combustion control for boilers with capacity ratings greater than 1,673,750 BTUH (490 kW). Locate flame scanner so that scanner can be tested and cleaned without burner disassembly.

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11.3.2.5 Fuel Trains: Provide fuel train per ASME CSD-1 and these additional requirements. The following safety interlock switches and limit controls required by ASME CSD-1 for gas-fired burners with an input greater than 5,000,000 Btu/hr (1465 kW) shall be extended to all gas-fired burners with an input of 400,000 Btu/hr (117 kW) and greater:

- a. The safety shutdown due to loss of combustion air
- b. The safety shutdown due to high or low pressure in the gas piping
- c. The fuel gas piping safety shut-off valves

11.3.2.6 Boiler Controls: Mount controls, including operating switches, indicating lights, gages, alarms, motor starters, fuses, and circuit elements of the control systems, on a single control panel that is not mounted on the burner. Locate the panel at the side of the boiler or in a freestanding control cabinet away from the front of the boiler. Control enclosures shall conform to NEMA Type 12. Provide control panel indicating lights as follows:

1. Amber: Ignition on
2. Blue: Draft
3. Green: Main fuel safety shut-off valves open
4. Red (One for each): Safety lockout, flame failure, high temperature, low water pressure, low water level, high gas pressure, low gas pressure.

a. Each safety interlock requiring a manual reset shall have an individually labeled red indicating light. Non-recycling control interlocks shall have the reset located on control interlock itself. Red indicating lights on the control panel may be omitted if the burner combustion control system has a Keyboard Display Module installed that will identify the lockout information required in Item 4 above.

b. Combustion Regulator: Provide adjustable temperature, thermostatic immersion regulator that limits boiler water temperature to 250 degrees F (121 degrees C) maximum. Control shall actuate burner to maintain boiler water temperature within prescribed limits at loads within rated boiler capacity.

c. Safety Controls: Each of the following controls shall cause a safety shutdown by closing fuel valves, shutting down burner equipment, activating a red indicating light, and sounding an alarm in the event that boiler water temperature rises to the high temperature limit setting. A safety shutdown shall require manual reset before operation can resume and shall prevent recycling of the burner equipment.

(1) High Temperature Limit Switch: Provide immersible aquastat type with a temperature setting above that of the combustion regulator and below that of the saturation temperature corresponding to the lowest relief valve setting.

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(2) Low Water Pressure Control: Provide mercury switch type. Control shall have a main scale, adjusting screws at the top of the case, and internal or external bellows. Control shall open an electric circuit on a drop in pressure below a set minimum.

(3) Low Water Level Cutoff Switch: Provide float-actuated type.

d. Boiler Safety Control Circuits: In addition to circuit grounds, ground metal parts that do not carry current to a grounding conductor.

e. Alarm Bell: Provide alarm bell not less than 4 inches (100 mm) in diameter, electrically operated, with a manual override. Override shall be configured so that silencing alarm following a safety shutdown will not prevent alarm from sounding again upon recurrence of a subsequent safety shutdown condition.

f. Post-Combustion Purge: Ensure operation of draft fan for a period of not less than 15 seconds, or of sufficient duration to provide the appropriate number of air changes in the boiler combustion chamber, (whichever is greater) following shutdown of burner upon satisfaction of heat demand. Upon completion of post-combustion purge period, draft fan shall automatically shutdown until next restart.

g. Safety Relief Valve: Relief valve piping shall conform to ASTM A 53, schedule 40 steel pipe.

h. Boiler Drain: Provide piping to a floor drain.

11.3.3 Hot Water System Accessories

a. Makeup Water Station: Provide a pressure-reducing valve and relief valve in the make-up water line to the boiler to maintain the operating pressure. Provide a 3/4 inch (20-mm) globe valve by-pass around the pressure reducing station. Provide backflow preventer upstream of by-pass.

b. Pressure Gages: Provide pressure gages with scale equivalent to 1.5 times the outlet water pressure on supply water piping and return water piping to boiler.

c. Thermometers: Provide thermometers with scale equivalent to 1.5 times the outlet water temperature on supply water piping and return water piping.

d. Chemical Treatment: Provide a shot-type feeder for manual chemical feed. Feeder shall be rated for use with pressures up to 200 PSIG (1379 kPa gage).

e. Air Vent Valve: Provide with screwed connection, stainless steel disk, and stainless steel seats to vent entrapped air.

11.3.4 Boiler Stack And Accessories

- a. Stack: Provide boiler stack constructed of sheet steel at least (2.47 mm) 3/32 inches thick with welded joints. Stack shall conform to NFPA 211.
- b. Insulation: Insulate portion of stack located inside the building with (38 mm) 1-1/2 inches of mineral wool conforming to ASTM C 592, Class II - for use up to (649 degrees C) 1200 degrees F. Coat insulation with finishing cement, (20 mm) 3/4 inches thick (minimum), trowelled to a smooth finish.
- c. Supports Provide stack supports, umbrella collar and cap, and flue transition piece.
- d. Stack Thermometer: Provide flue gas dial type thermometer with scale calibrated from 150 degrees F to 750 degrees F (66 degrees C to 399 degrees C) and mount in flue gas outlet.

11.3.5 Boiler Startup And Operational Tests

- a. Boiler Cleaning: Prior to startup the boiler shall be boiled out for 24 hours at 12 PSIG (83 kPa gage) (maximum). Boiling solution shall consist of 2 pounds (0.9 kg) of trisodium phosphate per 100 gallons (379 liters) of water. After cleaning, flush boiler with potable water, drain, and charge with chemically treated water. Professional services are required for the cleaning/treatment process.
- b. Operational Tests: Furnish the services of an engineer or technician approved by the boiler manufacturer for installation, startup, operational and safety testing. This person shall remain on the job until each boiler has been successfully operated for at least 3 days. Furnish and perform everything required for inspections and tests of the boiler and auxiliary equipment. Test instrumentation shall be calibrated and have full-scale reading from 1.5 to 2 times test values. Demonstrate proper operability of combustion control, flame safeguard control, and safety interlocks. Provide a detailed description of all boiler startup and operational tests in the Commissioning Plan.
- c. Acceptance Operational Test: Prior to requesting an acceptance test, conduct a satisfactory operational test for at least 8 hours, and provide a certified statement that the equipment is installed per all requirements of this guide. The Contracting Officer, upon receipt of the notice from the Contractor, shall request a boiler inspection by a Southern Division Boiler Inspector, Code 162CM. Twenty-one days advance notice is required for scheduling the inspector to conduct the acceptance operational test.

11.4 Power Piping Systems

11.4.1 Interior Piping: Interior piping shall conform to ANSI B31.1, "Power Piping Code" and/or ANSI B31.9, "Building Services Piping Code" as appropriate. Do not route steam piping within or above non-industrial areas.

11.4.2 Exterior Piping: Exterior piping shall conform to ANSI B31.1, "Power Piping Code" and/or B31.9, "Building Services Piping Code" as appropriate, and MIL-HDBK-1003/8, "Exterior Distribution of Utility Steam, High Temperature Hot Water, Chilled Water, Fuel Gas, and Compressed Air."

11.4.3 Prefabricated, Pre-insulated Piping With Outer Conduit: The design/build contractor shall be responsible for establishing the site, soil, and groundwater conditions in which the piping will be installed. The piping system manufacturer shall be responsible for design, fabrication, and witnessing installation and testing of the system within the design parameters established by the design/build contractor. Avoid direct buried piping in conduit where possible. Trench or aboveground systems are preferred.

TABLE 1- OUTSIDE DESIGN TEMPERATURES - °F								
State	Area	LAT	winter DB	summer		daily range	*	weather region
				DB	WB			
Alabama	Mobile	30	29	93	80	20	H	10
Florida	Cecil Field NAS	30	31	93	80	21	H	10
	Jacksonville	30	34	92	81	17	H	10
	Key West NAS	24	55	90	81	10	H	10
	Mayport	30	35	89	80	15	H	10
	Orlando	28	38	93	79	19	H	10
	Panama City	30	33	90	81	14	H	10
	Pensacola	30	30	91	81	15	H	10
	Whiting Field	30	29	93	79	21	H	10
	Cape Canaveral	28	38	88	80	15	H	10
Georgia	Albany	31	29	95	80	22	H	10
	Athens NSC	34	22	92	74	23	-	08
	Atlanta NAS	34	21	92	74	23	-	10
	Kings Bay	30	31	92	81	17	H	10
Illinois	Glenview NAS	42	0	89	74	15	-	06
	Great Lakes	42	0	89	74	15	-	06
Indiana	Indianapolis	39	2	90	74	23	-	06
	Crane NWS	38	9	92	75	25	-	07
Kansas	Kansas City	39	6	96	74	21	-	07
Louisiana	Barksdale AFB	32	24	94	77	22	-	11
	New Orleans	30	31	91	82	16	H	10
	Bay St. Louis	30	31	91	82	16	H	10
Mississippi	Gulfport	30	31	92	82	15	H	10
	Keesler AFB	30	31	92	82	15	H	10
	Meridian	32	21	93	76	24	-	08
	Pascagoula NS	30	31	92	82	15	H	10
Ohio	Cleveland	41	5	88	72	24	-	06
South Carolina	Beaufort MCAS	32	27	92	81	18	H	11
	Charleston	33	27	91	81	19	H	11
	Parris Island	32	27	92	81	18	H	11
	Shaw AFB	34	25	95	76	20	-	11
Tennessee	Memphis NSA	35	17	93	77	20	-	08
Texas	Corpus Christi	28	38	91	82	12	H	10
	Ingleside NAS	28	38	91	82	18	H	10
	Kingsville NAS	27	35	95	81	18	H	10
	Fort Worth JRB	32	23	99	75	22	-	11

* H designation identifies locations that are considered humid areas. See section 4 for special criteria to be used in humid areas.

TABLE 1- OUTSIDE DESIGN TEMPERATURES - °C								
State	Area	LAT	winter DB	summer		daily range	*	weather region
				DB	WB			
Alabama	Mobile	30	-1.7	33.9	26.7	11.1	H	10
Florida	Cecil Field NAS	30	-0.6	33.9	26.7	11.7	H	10
	Jacksonville	30	1.1	33.3	27.2	9.4	H	10
	Key West NAS	24	12.8	32.2	27.2	5.6	H	10
	Mayport	30	1.7	31.7	26.7	8.3	H	10
	Orlando	28	3.3	33.9	26.1	10.6	H	10
	Panama City	30	32.2	27.2	7.8	14	H	10
	Pensacola	30	-1.1	32.8	27.2	8.3	H	10
	Whiting Field	30	-1.7	33.9	26.1	11.7	H	10
	Cape Canaveral	28	3.3	31.1	26.7	8.3	H	10
Georgia	Albany	31	-1.7	35.0	26.7	12.2	H	10
	Athens NSC	34	-5.6	33.3	23.3	12.8	-	08
	Atlanta NAS	34	-6.1	33.3	23.3	12.8	-	10
	Kings Bay	30	-0.6	33.3	27.2	9.4	H	10
Illinois	Glenview NAS	42	-17.8	31.7	23.3	8.3	-	06
	Great Lakes	42	-17.8	31.7	23.3	8.3	-	06
Indiana	Indianapolis	39	-16.7	32.2	23.3	12.8	-	06
	Crane NWS	38	-12.8	33.3	23.9	13.9	-	07
Kansas	Kansas City	39	-14.4	35.6	23.3	11.7	-	07
Louisiana	Barksdale AFB	32	-4.4	34.4	25.0	12.2	-	11
	New Orleans	30	-0.6	32.8	27.8	8.9	H	10
	Bay St. Louis	30	-0.6	32.8	27.8	8.9	H	10
Mississippi	Gulfport	30	-0.6	33.3	27.8	8.3	H	10
	Keesler AFB	30	-0.6	33.3	27.8	8.3	H	10
	Meridian	32	-6.1	33.9	24.4	13.3	-	08
	Pascagoula NS	30	-0.6	33.3	27.8	8.3	H	10
Ohio	Cleveland	41	-15.0	31.1	22.2	13.3	-	06
South Carolina	Beaufort MCAS	32	-2.8	33.3	27.2	10.0	H	11
	Charleston	33	-2.8	32.8	27.2	10.6	H	11
	Parris Island	32	-2.8	33.3	27.2	10.0	H	11
	Shaw AFB	34	-3.9	35.0	24.4	11.1	-	11
Tennessee	Memphis NSA	35	-8.3	33.9	25.0	11.1	-	08
Texas	Corpus Christi	28	3.3	32.8	27.8	6.7	H	10
	Ingleside NAS	28	3.3	32.8	27.8	6.7	H	10
	Kingsville NAS	27	1.7	35.0	27.2	10.0	H	10
	Fort Worth JRB	32	-5.0	37.2	23.9	12.2	-	11

* H designation identifies locations that are considered humid areas. See section 4 for special criteria to be used in humid areas.

TABLE 2- FACILITY TYPE CATEGORIES		
FACILITY TYPE	FACILITY FUNCTION	LIMITATIONS
A1	Admin, Operations, Office, Police Stations	> 8000 ft ² (743.2 m ²)
A2		8000 ft ² or less (743.2 m ²)
B	Hospital Buildings	None
C	Medical Laboratories	None
D	Dental Clinics	None
E	Dispensaries	None
F	Prisons	None
G	Schools, Training & Education Centers, Childcare	None
H	Fire Stations	None
J	Post Offices, Chapels, Banks, Libraries, Credit Unions, Thrift Shops, Misc. Recreation Buildings, Arts & Crafts Buildings	None
K	Gyms, Indoor Pool Buildings, Field Houses, Cadet Activity Buildings	None
L	Clubs (NCO, Officer's, Recreation, Youth Center)	None
M	Theaters, Passenger Terminals	None
N	Dining Hall, Cafeteria, Snack Bar, Open Mess, Restaurants None	
O	Auditoriums	None
P	Museums	None
Q	BEQ, BOQ, Dormitories, Transient Billeting, Cadet Housing	None
R	Storage (Medical, Munitions, Range Targets, Forms), Medical Logistics, Kennel Support, Material Process Depot	None
S	Storage (Freight, Missile, Ammunitions), Aircraft Shelter, Air Freight Terminal, Range Supplies & Equip. Storage, Indoor Small Arms Range, Parking Shed, Depot Warehouse, Hazardous Material Storage	None
T	Cold Storage	None
U1	Maintenance (Hangars, Tactical Shops, Docks, Vehicle Facilities) High Bay Tech Training Areas (Flight Simulators)	Ceilings > 10 ft (3.048 m)
U2		Ceilings < 10 ft (3.048 m)
V	Commissary, Base Exchange, Package Store, Service Outlet	None
W	Electronics, Labs, Control Towers, Communications Facilities, Instrument Shops	None
X	Utility Plants (Boiler, Electricity Production, Sewage Treatment, Chiller)	None

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TABLE 3 - DESIGN ENERGY TARGETS (DET) I-P UNITS (1,000 Btu/ft ² /yr)								
FACILITY TYPE	WEATHER REGION						HOURS PER DAY	DAYS PER WEEK
	6	7	8	9	10	11		
A1	40.5	36.0	31.5	31.5	36.0	36.0	10	5
A2	36.0	31.5	31.5	27.0	31.5	31.5	10	5
B	121.5	94.5	90.0	90.0	94.5	99.0	24	7
C	40.5	31.5	31.5	31.5	31.5	31.5	10	5
D	58.5	49.5	45.0	36.0	40.5	54.0	10	5
E	58.5	45.0	40.5	31.5	36.0	49.5	10	5
F	45.0	40.5	40.5	36.0	40.5	45.0	24	7
G	54.0	45.0	31.5	31.5	40.5	45.0	10	5
H	49.5	40.5	36.0	27.0	31.5	40.5	24	7
I	49.5	40.5	36.0	27.0	31.5	40.5	10	5
J	49.5	40.5	36.0	31.5	36.0	36.0	10	5
K	45.0	45.0	36.0	36.0	40.5	45.0	16	7
L	58.5	58.5	54.0	49.5	58.5	58.5	16	7
M	49.5	45.0	45.0	40.5	45.0	45.0	8	7
N	54.0	54.0	49.5	49.5	58.5	63.0	16	7
O	36.0	31.5	22.5	22.5	22.5	27.0	3	5
P	36.0	27.0	22.5	18.0	18.0	22.5	10	5
Q	40.5	40.5	40.5	36.0	40.5	45.0	16	7
R	45.0	36.0	31.5	22.5	27.0	40.5	24	7
S	22.5	18.0	13.5	13.5	18.0	18.0	24	7
T	76.5	76.5	72.0	63.0	67.5	81.0	24	7
U1	67.5	58.5	49.5	45.0	63.0	63.0	24	6
U2	54.0	45.0	45.0	40.5	45.0	54.0	24	6
V	63.0	58.5	49.5	49.5	49.5	58.5	12	6
W	54.0	49.5	40.5	36.0	40.5	49.5	10	5
X	18.0	18.0	18.0	13.5	18.0	18.0	24	7

TABLE 3 - DESIGN ENERGY TARGETS (DET) SI UNITS								
(kWh/m²/yr)								
FACILITY TYPE	WEATHER REGION						HOURS PER DAY	DAYS PER WEEK
	6	7	8	9	10	11		
A1	127.8	113.6	99.4	99.4	113.6	113.6	10	5
A2	113.6	99.4	99.4	85.2	99.4	99.4	10	5
B	383.3	298.1	284.0	284.0	298.1	312.3	24	7
C	127.8	99.4	99.4	99.4	99.4	99.4	10	5
D	184.6	156.2	142.0	113.6	127.8	170.4	10	5
E	184.6	142.0	127.8	99.4	113.6	156.2	10	5
F	142.0	127.8	127.8	113.6	127.8	142.0	24	7
G	170.4	142.0	99.4	99.4	127.8	142.0	10	5
H	156.2	127.8	113.6	85.2	99.4	127.8	24	7
I	156.2	127.8	113.6	85.2	99.4	127.8	10	5
J	156.2	127.8	113.6	99.4	113.6	113.6	10	5
K	142.0	142.0	113.6	113.6	127.8	142.0	16	7
L	184.6	184.6	170.4	156.2	184.6	184.6	16	7
M	156.2	142.0	142.0	127.8	142.0	142.0	8	7
N	170.4	170.4	156.2	156.2	184.6	198.8	16	7
O	113.6	99.4	71.0	71.0	71.0	85.2	3	5
P	113.6	85.2	71.0	56.8	56.8	71.0	10	5
Q	127.8	127.8	127.8	113.6	127.8	142.0	16	7
R	142.0	113.6	99.4	71.0	85.2	127.8	24	7
S	71.0	56.8	42.6	42.6	56.8	56.8	24	7
T	241.4	241.4	227.2	198.8	213.0	255.6	24	7
U1	213.0	184.6	156.2	142.0	198.8	198.8	24	6
U2	170.4	142.0	142.0	127.8	142.0	170.4	24	6
V	198.8	184.6	156.2	156.2	156.2	184.6	12	6
W	170.4	156.2	127.8	113.6	127.8	156.2	10	5
X	56.8	56.8	56.8	42.6	56.8	56.8	24	7

TABLE 4- ECONOMIC LIFE EXPECTANCY OF MECHANICAL EQUIPMENT		
Category	Equipment	Life in Years
Air Conditioners and heat pumps	Window unit	10
	Residential packaged or split	15
	Residential water source	15
	Commercial through-the-wall	15
	Computer room	15
	Commercial packaged or split air-to-air	15
	Commercial water-to-air	19
	Commercial roof-top single zone	15
	Commercial roof-top multi zone	15
Boilers	Steel fire-tube	25
	Cast iron	35
	Electric	15
Furnaces	Gas or oil-fired	18
Unit heaters	Gas or electric	15
	Hot water or steam	20
Radiant heaters	Electric	10
	Hot water or steam	15
Fans	Centrifugal	25
	Propeller	15
Coils	DX, water, or steam	20
	Electric	10
Packaged Chillers	Reciprocating, water or air-cooled	20
	Scroll or screw, water or air-cooled	20
	Centrifugal	23
	Absorption	23
Cooling Towers	Galvanized steel	20
	Wood	20
	Ceramic or fiberglass	30
	Stainless steel	30
Ductwork		25

LIST OF REFERENCES

Note- Most Southern Division publications and Military Handbooks are available on the internet at Southern Division's website at:

http://www.efdsouth.navfac.navy.mil/Facilities_Acquisition/criteria/INDEX.HTM.

1. Southern Division Publications

- a. P-141, "Guide For Architect-Engineer Firms Performing Services For Southern Division Naval Facilities Engineering Command"
- b. "Index Of Criteria" - Includes guide specs, Design Manuals, Military Handbooks and other military publications.
- c. "Index Of Air Force Criteria" - Includes Force Manuals (AFM), Air Force Regulations (AFR), Air Force Instructions (AFI), Engineering Technical Letters (ETL) and other Air Force publications.
- d. Requirements Documents (for Air Force projects only).
- e. Parametric Cost Estimate (PCE) Package (for Navy and Marine Corps projects)

2. Military Handbooks

- a. MIL-HDBK-1003/17, Industrial Ventilation Systems
- b. MIL-HDBK-1012, Telecommunication Premises Distribution Planning, Design, and Estimating
- c. MIL-HDBK-1022, Petroleum Fuel Facilities
- d. MIL-HDBK-1191, Medical and Dental Treatment Facilities (use for breathing air)

3. U.S. Army Corps of Engineers Publications

- a. ACOE TI-809-04, Seismic Design for Buildings

4. U.S. Air Force Publications

- a. ETL 94-4, Energy Budget Figures for Facilities in the Military Construction Program
- b. AFOSH Std. 161-2 (ventilation)
- c. AFM 85-16, "Maintenance of Petroleum Systems"

5. Industry Publications

- a. The International Mechanical Code (IMC)
- b. The International Plumbing Code (IPC)
- c. ASHRAE Std. 15, Refrigeration Equipment Rooms
- d. ASHRAE Std. 62, Ventilation Requirements
- e. ASHRAE Systems and Equipment Handbook
- f. ASHRAE Guideline 1-1996, Commissioning

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- g. ANSI/ASHRAE 135-1995, BACnet
- h. SMACNA Seismic Restraint Manual
- i. NFPA 90A
- j. NFPA 90B
- k. MAIMA Publication AH124, "Fibrous Glass Duct Liner Standards"
- l. ACGIH, Industrial Ventilation